DSE-4

S-6/PHSH/DSE-IV/22

TDP (Honours) 6th Semester Exam., 2022

PHYSICS

(Honours)

FOURTH PAPER : DSE–IV

Full Marks : 80 *Time* : 3 Hours

The figures in the margin indicate full marks.

GROUP—A

1. Answer *any* **eight** questions : 2×8=16

(a) What do you mean by quantum dot? Give two examples of it.

(b) What is Coulomb blockade?

(c) What is sol and what is gel?

(d) Explain the process of ball milling.

(e) What do you mean by quasi-particle? Explain with example

(f) What do you mean by band offsets in heterojunction?

(g) What is the difference between resolution and magnification of a microscope?

(h) What is optical switching?

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(i) Write the differences between photo luminescence and electroluminescence.

(ii) What do you mean by hopping conductivity?

GROUP—B

(There are **four** questions from Question No. 2 to Question No. 5. Answer *either (a) or (b)* from each question.)

2. *(a)* (i) What do you mean by quantum confinement?

(ii) How are the DOS (density of states) changed with respect to energy in different dimensional nano-structured materials as a consequences of quantum confinement? Explain with diagram.

(iii) Write some properties of materials at nanometre size arised when derived from bulk material.

(iv) What do you mean by aspect ratio? How are the aspect ratio changed in nanomaterials when it is derived from bulk? Explain with suitable example.

2+6+4+4=16

(OR)

(b) (i) What is a quantum well?

(ii) Write the wave function of first three confined states and energies of the first three confined states of an infinite depth potential well with schematic diagram.

(iii) Explain the quantum transport in quantum dots.

(iv) Explain with schematic the occurrence of quantum conductance in quantum dot at different bias voltages. Also compare it with current-voltage characteristics of the corresponding bulk systems. 2+5+3+(3+3)=16

3. *(a)* (i) Explain top-down and bottom-up mechanism for synthesis of nanomaterials.

(ii) Write the merits and demerits of top-down and bottom-up technuques.

(iii) Describe the chemical vapour deposition method (CVD) of nanomaterial synthesis.

(iv) Explain how XRD is used for characterisation of nano-structured materials. (4+4+4+4)=16

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(OR)

(b) (i) Write the differences between PVD and CVD.

(ii) Describe the pulsed laser deposition method of nanomaterial synthesis.

(iii) Explain the working theory of AFM technique of nanomaterial characteristion. How is AFM used for characterisation of nano-structured materials.

(iv) Write about different types of Lithography. (3+5+5+3)=16

4. (a) (i) What do you mean by exciton? Discuss how energy band gaps are modified in semiconductor nanocrystals due to exciton.

(ii) Discuss some optical properties of nano-structured materials.

(iii) Write the reasons for change in optical properties of materials at nanoscale.

(iv) What do you mean by band-edge emmission and trap state emmission related to luminescence spectrum? (1+4)+4+3+4=16

(OR)

(b) (i) Discuss about different types of polarisation arising in dielectric material at nano-scale. Also show the graphically variation of real part of polarisation as a function of frequency.

(ii) What do you mean by direct and indirect transitions?

(iii) Describe the relation between the optical properties and the electronic structure of materials. How is it effected as nanoscale?

(iv) What do you mean by Franz-Keldysh effect? (3+2)+3+(3+2)+3=16

5. (a) (i) Describe how the nanomaterials are used in photonic device like LED and solar cells.

(ii) Explain how the concept of optical switching is used in optical data storage device.

(iii) What do you mean by single-electron tunneling phenomenon? Write the differences between single-electron transistor and normal transistor.

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(iv) Write two uses for both of nanostructured thin film and quantum dots. 5+4+4+3=16

(OR)

(b) (i) What is carbon nanotubes? Discuss about different types of carbon nanotubes.

(ii) Write and explain four excellent properties of carbon nanotubes.

(iii) Explain the concept of magnetic quantum well.

(iv) What do you mean by magnetoresistance? Describe different types of magnetoresistance. (1+4)+3+3+(1+4)=16

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PHYSICS

(Honours)

FOURTH PAPER : DSE – IV

Full Marks : 80 *Time : 3 Hours*

Answer from ***both*** *the Groups as directed.*

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP—A

1. Answer *any* **eight** of the following questions : 2×8=16

(a) What do you mean by nanostructured material?

(b) Write the importance of defects in nanomaterials.

(c) Draw the variation of Density of State (DOS) as a function of energy for 0-d and 2-D nanoparticles.

(d) What do you mean by radiative and non-radiative transitions?

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(e) What is physical vapour deposition technique?

(f) What is fluorescence?

(g) Can excitons be considered as quasiparticles? Justify your answer.

(h) What are nanowires? What unique properties do they possess at nanoscale?

(i) What properties of nanoparticles make it useful in the development of high performance electronic display?

(j) Define magnetoresistance.

GROUP—B

There are *four* questions from Question No. 2 to Question No. 5. Answer either *(a)* **or** *(b)* from each question given below : 16×4=64

2. *(a)* *(i)* How are the nanoscale systems different from bulk systems? Explain.

(ii) How are the nanoscale systems used in medicine and healthcare?

(iii) What are nanodots? What unique properties do they exhibit at the nanoscale?

(iv) What is tunnelling conductivity? How does it occur in nanoscale system? What factor influence the tunnelling conductivity of nanoscale structure?
3+3+(2+2)+(2+2+2)=16

(OR)

(b) *(i)* Explain the phenomenon of coulomb blockade in nanoscale system.

(ii) Explain the consequences of quantum confinement.

(iii) How do nanowires differ from nano-rods in terms of their structure and properties?

(iv) What is hopping conductivity? How does it occur in nanoscale system? How does it differ from metallic conductivity?
3+3+(2+2)+(2+2+2)=16

3. *(a)* *(i)* What is ball milling? How does it affect the structure, size and properties of nanoparticles? Write the advantages of using ball milling for nanomaterial synthesis compared to other methods.

(ii) What is top-down and bottom-up approach in nanoscience? Write the differences between these two techniques.

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(iii) Explain the working theory of SEM technique. (2+2+2)+(2+2+2)+4=16

(OR)

(b) (i) What are the key principles and processes involved in thermal evaporation, a type of physical vapour deposition technique? Write the advantages of this technique.

(ii) How does the sol-gel process contribute to the synthesis of nanomaterials? What are the key factors that influence the stability and homogeneity of sol-gel derived nanomaterials?

(iii) What information can we get from SEM image of nanomaterials? (2+3+3)+(3+3)+2=16

4. (a) (i) What are quasiparticles? How do they differ from elementary particles?

(ii) How do excitons and quasiparticles contribute to the understanding of optical properties and energy transfer in materials?

(iii) Write short notes on (a) surface plasmon resonance and (b) lithography. (2+2)+(3+3)+(3+3)=16

(OR)

(b) (i) What do you mean by Morse potential energy curve? Explain graphically.

(ii) State and prove Beer-Lambert's law. What are the limitations of it?

(iii) What is Luminescence? Write the difference between electro-luminescence and photoluminescence. (2+2)+(1+3+2)+(2+4)=16

5. (a) (i) Describe the working theory of a solar cell with schematic diagram.

(ii) How do different nanomaterials (both organic and inorganic) impact the performance of solar cell in terms of its figure of merit?

(iii) Explain the working of LEDs to achieve high efficiency light emission. Write two practical applications of LED. 5+5+(5+1)=16

(OR)

(b) (i) What is magnetic quantum well? How does it differ from a traditional quantum well structure? What are the unique properties and behaviours exhibited by electrons in a magnetic quantum well due to the presence of magnetic field?

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(ii) Do a comparative analysis of quantum dots, nanowires and thin films with respect to the application in photonic devices.

(iii) What is optical switching?

(2+2+2+2)+6+2=16

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TDP (Honours) 6th Semester Exam., 2024

PHYSICS

(Honours)

FOURTH PAPER : DSE – IV

Full Marks : 80 *Time : 3 Hours*

Answer from **both** *the Sections as directed.*

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

SECTION—A

1. *Answer any* **eight** *of the following questions :* 2×8=16

   (a) What is the difference between 1-D and 2-D nanomaterials?

   (b) What do you mean by nanoscience and what is its importance?

   (c) What is ball milling process?

   (d) Write the difference between top down and bottom up processes.

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(e) What information we can get from X-ray diffraction?

(f) What is spray pyrolysis?

(g) Define quasi particle and give some examples.

(h) What are single-walled and multi-walled carbon nanotubes (CNTs)?

(i) Define magnetic quantum well.

(j) Write some important applications of nano particles in electronic device fabrication.

SECTION—B

There are *four* questions from Question No. **2** to Question No. **5**. Answer either *(a)* **or** *(b)* from each question given below : 16×4=64

2. *(a)* *(i)* What do you mean by surface to volume ratio? Write its importance in nanostructure.

(ii) What is quantum confinement? How does it change the energy level of a nanomaterial?

(iii) Write Schrodinger's equation for a 1-D nanostructure and solve it. Calculate the energy level of the system.

(1+3)+(1+3)+(1+3+4)=16

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(OR)

(b) *(i)* Write short notes on the following :

I. Quantum dot

II. Quantum wire

(ii) Write Schrodinger equation for a step potential and solve it. Derive the expression for energy in this case.

(iii) What do you mean by tunneling and hoping conductivity? How do they work in case of conduction process through nanomaterials?

(3+3)+(1+3+2)+(2+2)=16

3. *(a)* *(i)* Explain in brief the different types of physical vapor deposition techniques for synthesis of nanostructure materials.

(ii) Write a short note on photolithography.

(iii) With a neat diagram, discuss the construction and working of transmission electron microscope. Write its some applications. 5+3+(6+2)=16

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(OR)

(b) (i) Discuss the construction and working of X-ray diffractometer. Write its some applications.

(ii) Write short notes on the following :

I. Pulsed laser deposition technique

II. Sol–gel process

(iii) Write three applications of Atomic Force Microscopy. (5+2)+(3+3)+3=16

4. (a) (i) What do you mean by exciton? Discuss how energy band gap in semiconductor nanocrystal can be modified due to exciton.

(ii) What do you mean by band-edge emission and trap state emission related to luminescence spectrum?

(iii) Write a short note on direct and indirect band gaps of semiconductor nanocrystal.

(iv) How does Coulomb interaction influence the electronic properties of nanostructure? (1+5)+4+3+3=16

(OR)

(b) (i) Discuss the reason for change in optical properties of materials at nanoscale.

(ii) Write the difference between photoluminescence and electroluminescence.

(iii) What do you mean by Morse potential energy curve? Explain with the help of graphical diagram.

(iv) What are the various factors that affect the resolving power of an optical instrument? 5+3+(2+3)+3=16

5. (a) (i) What do you mean by optical switching? Explain how it can be used in optical data storage device.

(ii) Explain how CNT can be used in fabrication of transistor. Write the advantage of it over ordinary transistor.

(iii) Explain how quantum dots can be used in LED device.

(iv) Write three applications of nanomaterials in medical field. (1+3)+(3+2)+4+3=16

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(OR)

(b) (i) Describe how nanomaterials can improve the performance of solar cell.

(ii) Write a short note on Micro Electromechanical Systems (MEMS).

(iii) What do you mean by thin film? How can they improve the performance of photonic device?

(iv) Describe about various magnetic storage devices. 5+3+(2+3)+3=16

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